International Journal for Computational Civil and Structural Engineering, 19(3)141–154(2023)

DOI:10.22337/2587-9618-2023-19-3-141-154

SEISMIC VULNERABILITY ASSESSMENT FOR BUILDINGS OF PORT BLAIR CITY USING RAPID VISUAL SCREENING AS A TOOL

Mr. Adharsh G. [1*]***, Dr. R. Sivakumar***[2]***, Dr. K.S. Satyanarayanan***[3]

[1*]**Affiliation 1:** S.A Engineering College, Poonamallee, Avadi Road Veeraraghavapuram, Thiruverkadu, Tamil Nadu, INDIA
[1*]**Affiliation 2:** Research Scholar, Department of Civil Engineering, Faculty of Engineering and Technology, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, Chengalpattu, Chennai TN, INDIA
[2] Department of Civil Engineering, Faculty of Engineering and Technology, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, Chengalpattu, Chennai TN, INDIA
[3] Department of Civil Engineering, Faculty of Engineering and Technology, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, Chengalpattu, Chennai TN, INDIA
[1*] Corresponding Author Email: profadharshg82072@gmail.com

Abstract: Andaman and Nicobar Islands is one of the most earthquake experienced areas around the world subjected to frequent earthquakes which is being the area of study using rapid visual screening (RVS) method by google maps and field visit as well. Although the google maps and internet sources can be used to cover up 80 percent data required for assessing and quantifying the RVS score but a field visit was made for extracting more relevant data for a detailed study. Port Blair municipal area was narrowed down for the screening since it had the greatest number of buildings. It was found that the moment resisting frames have been used in most of the buildings. RC moment resisting frames, load bearing structures, steel structures and wooden structures were studied in the screening and score was awarded. Gleaned from the score it was derived that old buildings are more susceptible for higher damage in near future then the recently constructed building.

Keywords: Damage assessment, Port Blair city, Rapid visual screening, Vulnerability assessment

ОЦЕНКА СЕЙСМИЧЕСКОЙ УЯЗВИМОСТИ ЗДАНИЙ В ГОРОДЕ ПОРТ-БЛЭР С ИСПОЛЬЗОВАНИЕМ МЕТОДА БЫСТРОГО ВИЗУАЛЬНОГО СКРИНИНГА

Адхарш Г. [1*]***, Сивакумар Р.*** [2]***, Сатьянараянан К.С.*** [3]

[1*] инженерный колледж, Пунамалли, Авади Роуд, Вирарагхавапурам, Тируверкаду, штат Тамилнад, ИНДИЯ; Институт науки и технологий, Нагар, Каттанкулатур, Ченгалпатту, Ченнаи, штат Тамилнад, ИНДИЯ
[2] Институт науки и технологии, Нагар, Каттанкулатур, Ченгалпатту, Ченнаи, штат Тамилнад, ИНДИЯ
[3] Институт науки и технологии, Нагар, Каттанкулатур, Ченгалпатту, Ченнаи, штат Тамилнад, ИНДИЯ
[1*] Email: profadharshg82072@gmail.com

Аннотация: Андаманские и Никобарские острова - один из наиболее сейсмоопасных районов мира, подверженный частым землетрясениям, и именно здесь проводилось исследование с использованием метода быстрого визуального скрининга (БВС) по картам Google и с выездом на место. Хотя карты Google и интернет-источники могут быть использованы для получения 80% данных, необходимых для оценки и проведения БВС, для получения более релевантных данных для детального исследования был проведен выезд на место. Муниципальный район Порт-Блэр был выбран для обследования, поскольку в нем находится наибольшее количество зданий. Было обнаружено, что в большинстве зданий использовались каркасы рамного типа. В ходе обследования были изучены железобетонные рамы, несущие конструкции, стальные и деревянные конструкции и выполнена оценка. На основании полученных оценок было сделано заключение, что старые здания более подвержены большим разрушениям в ближайшем будущем, чем недавно построенные.

Ключевые слова: Оценка ущерба, город Порт-Блэр, быстрое визуальное обследование, оценка уязвимости

1 INTRODUCTION

Andaman & Nicobar Islands lying in the Bay of Bengal is significantly one of the most vulnerable regions in terms of seismicity,[30] around the globe and is placed in zone V of Indian seismic zones. As per the national center of seismology, In India frequent earthquake occurs around the Islands in the Bay of Bengal Sea with an average of 30 earthquakes [27] [13] [28] every month *Source* After [25] [22] The Islands have also reached a population of 4 lakhs and have a high flow of tourists all over the world all these parameters show the importance of seismic studies in the Andaman & Nicobar Islands *Source* After Sarmah & Das, (2018) Port Blair which is the capital of the Andaman & Nicobar Islands is a fast-developing city that mainly is the home of the majority of reinforced concrete (RC) framed structures[19] [31] [32-34] Although the municipal regulatory board of the islands has set limitations on the height and number of floors for the RC structures as 15m or G+4 respectively, it was observed that the anchorage reinforcement was not adopted in 90% of the RC framed structures specified in IS13920:2016 ductile detailing for RC framed structures in Zone V[22-23] [26] Yadollahi.et.al.2012).[7] Though there are some studies for the geotechnical studies on the Islands unfortunately no study is found on the damage and risk assessment of the RC framed structures which is of high importance.[14] Fig 1 shows the epicenter distribution of the Andaman and Nicobar Islands where it is clearly shown the density of epicenters with a magnitude range of 6.5 – 8. A survey was conducted in the port Blair region for the existing buildings using rapid visual screening (RVS) developed by FEMA [15] *Source* After Federal Emergency Management Agency (2017) for the assessment of various types of buildings which were then used for classifying the buildings as per the damage conditions and suggestions were made or the building for further evaluation.[20] [21][24][29]

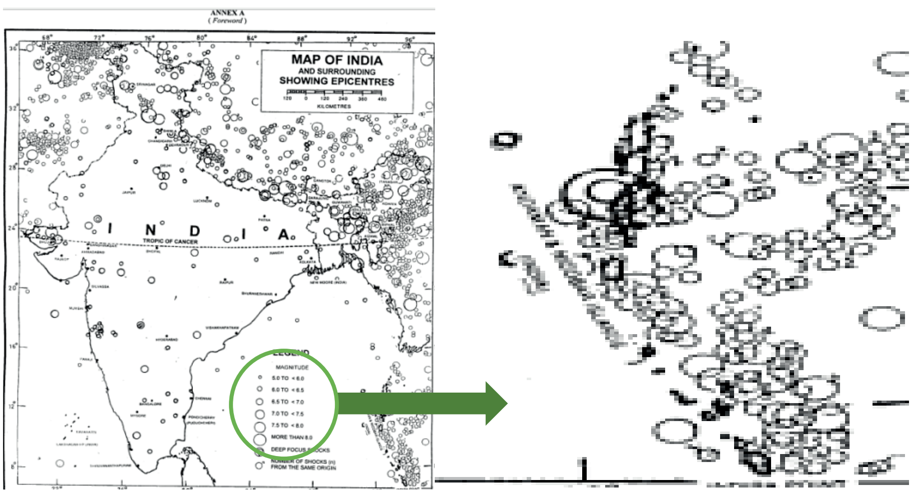


Figure 1. Epicenter distribution of Andaman and Nicobar Islands

2. LITERATURE REVIEW

Moustafa moufid Kasim and Salmia Beddu in 2021 approached the RVS method through a web-based method, where they used Google maps for data collection without physically going to the site. Around 500 buildings were selected and segregated as per plan irregularity and vertical irregularity which was taken from the street view function. A hazard map was plotted and further, it was directed for a detailed study *Source* After [18]
Additionally, Tanya Sharma and Sutapa Das in 2019 [1] conducted the rapid visual screening for 100 buildings which were randomly selected and categorized in 9 major vulnerability parameters using US FEMA *Source* After Federal Emergency Management Agency (2017) guideline

3. STUDY AREA

3.1 Geological & Soil profile

The Andaman & Nicobar Island group, situated 1200 km south east of the mainland in the Bay of Bengal *Source* After [6] The main agricultural soils are found in the valleys and are of alluvial and colluvial origin and sandy clay to sandy loam in texture *Source* After Subramani & Gangaiah. The pH of soils is normal for 55.3 and 72.4 % soils of Andaman and Nicobar districts *Source* After Subramani & Gangaiah.

3.2 Seismic History

The Islands have experienced numerous earthquakes in its life span. Although the numbers are not recorded precisely before 19th century. In this paper the seismic events pre–and post-independence are discussed. On 26 June 1941 a huge magnitude earthquake occurred with an epicentral distance of 60kM from South Andaman causing major and damages to masonry structures including the collapse of cellular jail's central watch tower *source* after [6]. Till the 2004 earthquake there was not a substantial high magnitude earthquake recorded which were almost less than 6 (M<6), however a moderate earthquake was recorded 20 January 1992 with a magnitude of 6.9, and a similar earthquake again hit the islands with a magnitude of 6.5 on 13 September 2002. On 2004 the islands experienced its highest magnitude earthquake ever recorded of 9.3. after the 2004 earthquake many seismic events were recorded with mild magnitude till date.

4.SCREENING METHODOLOGY

The study aimed to create a hazard profile of Port Blair city. As this was the city's first study of its kind, the building samples were chosen randomly within a zone. The RC framed buildings are generally susceptible to getting damaged if it has irregularity of shape in plan and elevation, hence two types of screening methods were adopted

4.1 Google earth images (GEI)

Google Earth images (GEI) is a free source through which the area and the dimensions of the building can be calculated for preliminary screening. Using GEI, it was found that most of the RC buildings were symmetrical in shape. Around 100 buildings were selected from higher altitudes as samples by switching the satellite view to terrain view in GEI from the study area randomly and only 5 buildings had plan irregularity. The preliminary survey using GEI showed buildings are vulnerable due to plan irregularity as 5%.

Figure 2. Building sampling using Google earth images (GEI)

4.2 Rapid Visual Screening (RVS

RVS method is one of the most widely used methods for initial screening of buildings that are in seismic zones, since it is simple, anyone with no technical knowledge can survey the buildings and fill out the form *source* after [4]. The RVS form was generated by the federal emergency management agency (FEMA) which created it for low, moderate, and high seismic zones and as far as the Indian version of RVS is concerned it has been modified for masonry buildings and RC structures for five different seismic zones. The survey forms can be customized as per the need which is the major advantage of the tool *Source* after [11]

4.3 Building possession

All the buildings were roped into 10 categories according to their building possession- Residential, Commercial, Industrial, Government, Office, School, Hospital, Religious, Storage, Transportation, Unknown and Mixed Use

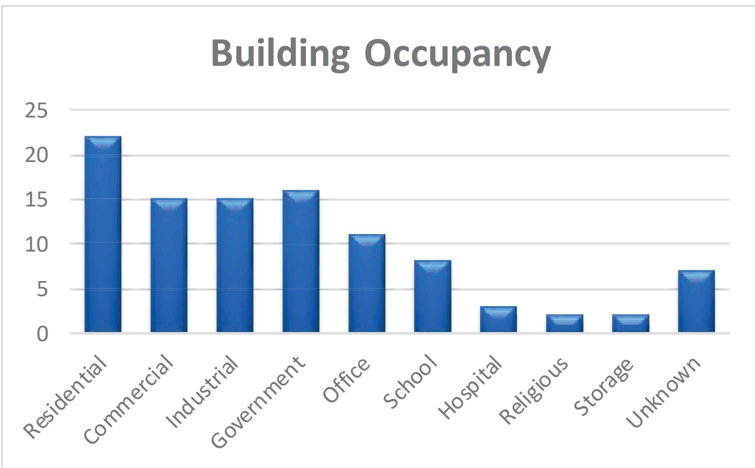


Figure 3. Distribution contribution of building occupancy

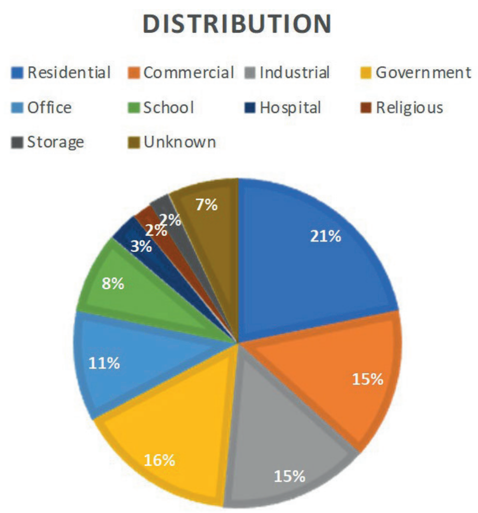
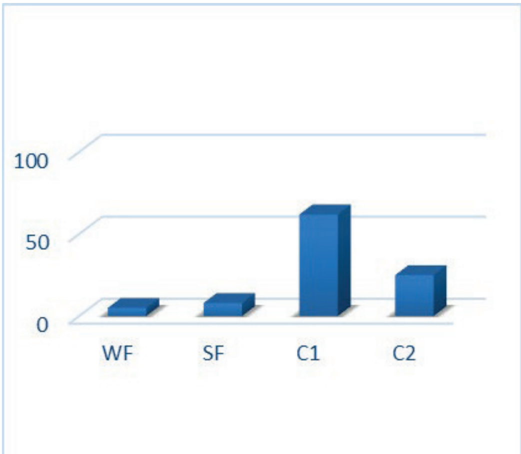


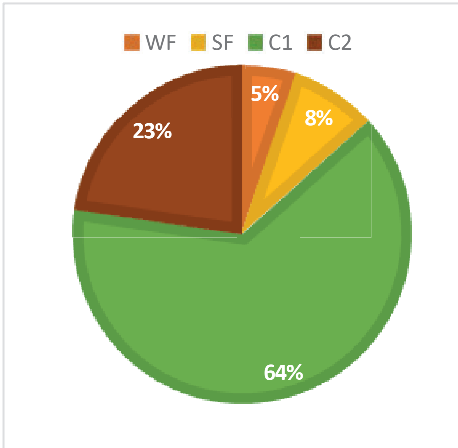
Figure 4. Percentage Distribution of building occupancy

4.4 Building Type

On account to the survey conducted only 5 types of building were found in the city which were wood frame (WF), Steel frames (SF), Concrete moment resisting frame (C1), Concrete frame with masonry infill (C2). Figure 5 shows the distribution of the 100 building samples distribution according to its building type. Most of the buildings were newly constructed due to the increase in tourism and steel structures were limited and very few truss and bridge decks were made of steel elements. Wooden structures were very less in numbers with only single storey buildings.



(a)



(b)

Figure 5. (a) Distribution contribution of building type (b) Percentage distribution of building type

4.5 Building sample

In Port Blair city, a total of 75 building was surveyed using the RVS sheet. The sample consisted of 60 RCC buildings with normal slabs and steel roof trusses and 10 other types of buildings which were non-engineered buildings with low-risk profiles consisting of timber structures. The RCC buildings sampled were a mixture of old buildings to newly constructed buildings. As the city is now a tourism hub, most RC buildings were private hotels and residencies. The buildings were observed for 3 to 5 minutes and the survey form was filled *source* after [12]

a) b) c)

Figure 5. (a) area covered in the city (b) & (c) Elevation and external condition of building samples

5. DETAILED VISUAL INVESTIGATION

The buildings were further investigated to find if any deep damage traces are found in the structure. As a result, it was observed that out of 75 sampled structure 3 buildings were damaged severely in the beam column section and required immediate repairing. The damaged buildings were constructed well before 30 years as per the local sources. The major damage was found in the buildings after the 2004 earthquake as per local sources. A high magnitude earthquake may cause severe damage and lead the deterioration of the structures [16] As per the local construction engineer no buildings were constructed with refence to IS codes source after [17], (Yang & Goettel,et.al.2007), (Yadollahi, et al.2012).

(a) (b) (c)

Figure 6. (a), (b) & (c) Damaged beam and column in three different schools of Port Blair

6. BUILDING CONSTRUCTION REQUIRED

According to IS13920:2016 the required ductile detailing in seismic zone V, in an external joint, all the longitudinal bars shall be well provided with anchorage length away from the inner face of the column, equal to the development length in tension plus 10 times the bar diameter minus the allowance for 90-degree bend('s) and in internal joints both face bars of the beam shall be taken continuously through the column *Source* after BIA (1996)

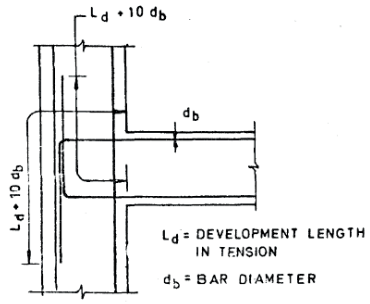


Figure 7. Beam-column joint required in a highly seismic area building [3]

7. STATE OF DAMAGE AND RVS SCORE

As per the data analyzed in the sheets, RVS scores were calculated. The score suggests the damage level of the building in the near future due to earthquake or other dynamic loads with respect to all the parameters

Table 1. RVS score and potential damage of building with reference to European Macro-seismic Scale (EMS-98) source after Graziani, et al., (2019)

RVS Score	Potential Damage	Damage Description
RS < 0.3	Most likely to get Class 5 damage; Very high chance of Class 4 damage	**Destruction** (In-depth structural system damage) Ground floor collapse (e.g., building wings)
0.3 < RS < 0.7	Most likely to get Class 4 damage; Very high chance of Class 3 damage	**Very hefty damage** (Substantial structural system damage, massive non-structural damage) Heavy cracks in structural elements with concrete compression failure and steel fractures; bond failure of reinforcing bars; camber of columns.
0.7 < RS < 2.0	Most likely to get Class 3 damage; Very high chance of Class 2 damage	**Substantial to hefty damage** (Average structural damage, hefty non-structural damage) Column cracks and beam-column joints, at coupled wall joints, concrete cover spalling and buckling of reinforced bars.
2.0 < RS < 3.0	Most likely to get Class 2 damage; Very high probability of Class 1 damage	**Medium Damage** (Minor structural damage, medium non-structural damage) Cracks in structural members.
RS > 3.0	Most likely to get Class 1 damage	**Negligible to minor damage** (Nil structural damage, minor non-structural damage) Hair cracks in the upper layer over frame members or in walls at the base. Hair cracks in partition walls and infills.

Table 2 RVS score performance of buildings

RVS Score	Damage Class	Number of buildings			
		WF	SF	C1	C2
RS < 0.3	5	0	0	1	1
30.3 < RS < 0.7	4	0	0	16	2

RVS Score	Damage Class	Number of buildings			
		WF	SF	C1	C2
0.7 < RS < 2.0	3	0	0	15	6
2.0 < RS < 3.0	2	2	3	19	4
RS > 3.0	1	3	5	11	12

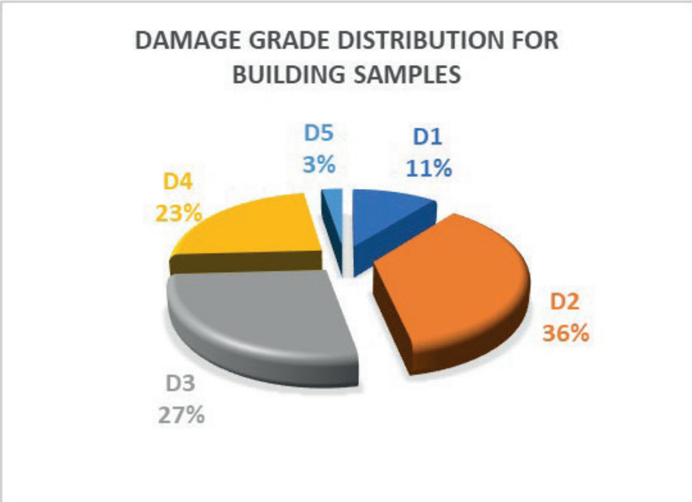


Figure 6. *Damage grade distribution of all the building samples assessed*

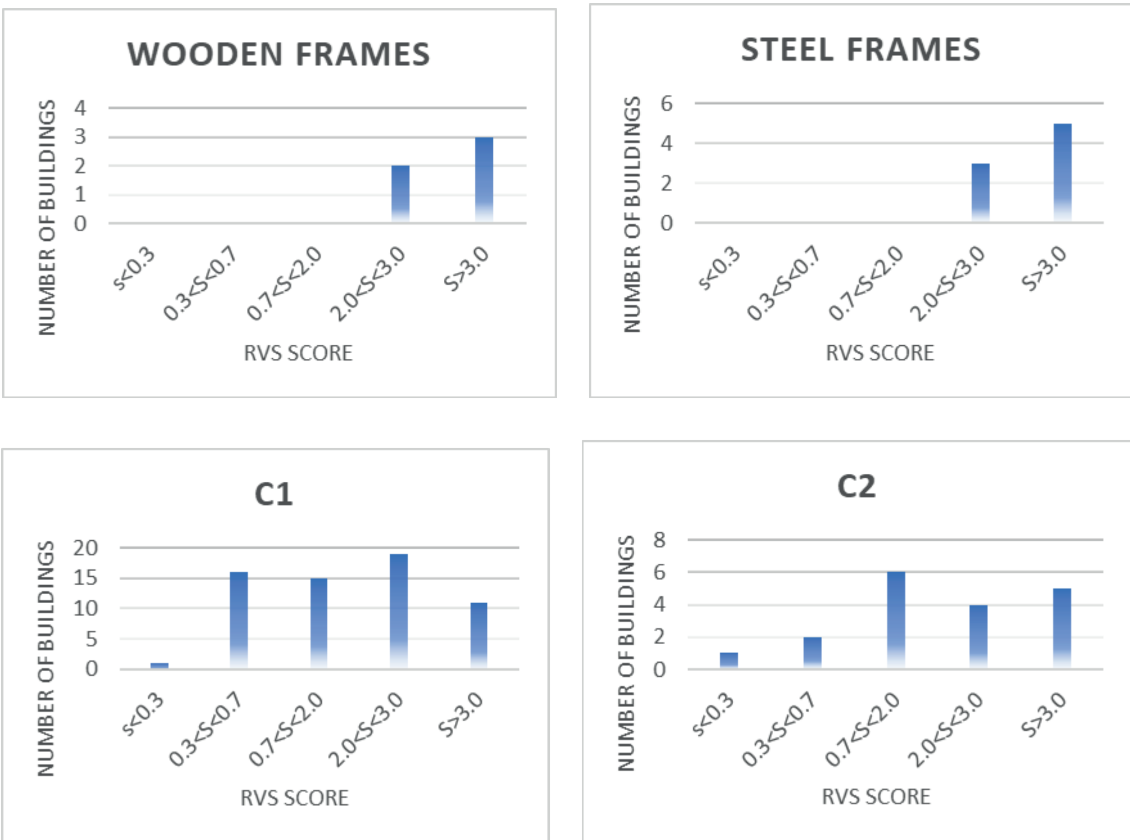


Figure 7. *RVS score of corresponding building types*

A total of 5 wooden frames were assessed during RVS out of which two buildings showed three buildings were used as ware houses which substantially showed grade 2 damage and two buildings that were not much used in the past showed grade 1 damage. 8 steel frames were observed in which were mostly used as workshops and motor garages, 3 frames were drafted under grade 2 damage where a slight crack were observed near the steel column and connected walls though the remaining 5 trusses were classified under grade one damage due to zone severity.

The majority of the building in the inspected area were found to be moment resisting RC frames(C1) in which 62 buildings were visited for screening. 11 framed buildings were grouped in grade 1 damage due to their plan and elevation regularity. 19 buildings were grouped under grade 2 damage due their plan and vertical irregularity being the reason of grading in the majority of building which were also constructed in sloped areas. The C1 type building were less in numbers in which 1, 2, 6, 4, and 12 number of buildings were grouped under grade 5, 4, 3, 2, and 1 respectively.[8] [9] [10].

8. CONCLUSION

For the development and safety of the residents of Port Blair city and due to the large inflow of tourism every year in the Islands, it is very important to study the remaining area of the city for the damage assessment and present conditions of the building. As the survey was conducted within a small scale of 75 buildings most of the buildings were residential and a very small percentage of buildings were used for commercial purposes. The following points were concluded after the study using RVS as a tool to measure the damage of buildings in the future.

1. The Rapid visual screening tool could be used for the initial screening of buildings through google maps where the plan irregularity in plan can be find out and further study can be done if the full-scale picture is available through internet sources of all the buildings of the selected area.
2. All though the Port Blair city has shown a steady growth in their infrastructure development and doesn’t show much negative values while screening but the construction practice adopted in the Islands doesn’t meet the regulations of IS13920:2016 of ductile design.
3. The old buildings which were observed were 50 years old in average which showed significant damage in the crucial areas such as beam column joint.
4. As the city is of national importance, more detailed visual screening and deep inspection is needed for the buildings which showed the sign of vulnerability during the present study

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Mr. Adharsh G. **Affiliation 1:** Assistant Professor, Department of Civil Engineering, S.A Engineering College, Poonamallee, Avadi Road Veeraraghavapuram, Thiruverkadu, Tamil Nadu, INDIA; **Affiliation 2:** Research Scholar, Department of Civil Engineering, Faculty of Engineering and Technology, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, 603203, Chengalpattu, Chennai TN, INDIA. Email: profadharshg82072@gmail.com

Dr. R. Sivakumar, Professor, Department of Civil Engineering, Faculty of Engineering and Technology, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, 603203, Chengalpattu, Chennai TN, INDIA. Email: profadharshg82072@gmail.com

Dr. K.S. Satyanarayanan Professor, Department of Civil Engineering, Faculty of Engineering and Technology, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, 603203, Chengalpattu, Chennai TN, INDIA. Email: profadharshg82072@gmail.com

Адхарш Г., доцент, кафедра гражданского строительства, инженерный колледж, Пунамалли, Авади Роуд, Вирарагхавапурам, Тируверкаду, штат Тамилнад, Индия; Научный сотрудник, кафедра гражданского строительства, факультет инженерии и технологий, Институт науки и технологий, Нагар, Каттанкулатур, 603203, Ченгалпатту, Ченнаи, штат Тамилнад, Индия. Эл. почта: profadharshg82072@gmail.com

Сивакумар Р., профессор кафедры гражданского строительства инженерно-технологического факультета Института науки и технологии, Нагар, Каттанкулатур, 603203, Ченгалпатту, Ченнаи, штат Тамилнад, Индия. Эл. почта: profadharshg82072@gmail.com

Сатьянараянан К.С., профессор кафедры гражданского строительства инженерно-технологического факультета Института науки и технологии, Нагар, Каттанкулатур, 603203, Ченгалпатту, Ченнаи, штат Тамилнад, Индия. Эл. почта: profadharshg82072@gmail.com